Third-space Architecture for Learning in 3D

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Keywords: Visual simulation, model-based reasoning, learning in 3D, virtual environments

Abstract

Learning can be increasingly untethered to home, work or school spaces by means of integrative cloud services coupled with 3D worlds, and mobile, collaboratively driven use of digital "third space." A 3rd-space, portable and modular design is described and demonstrated for use in administering and supporting learning in 3D. 3rd-space environments can be designed for enabling multi-purpose, multifunctional devices and tools for learner-centered design and collaborative social learning. The framework offered in this paper supports multiple delivery options involving offline and online access to an OpenSim platform for learning in 3D and the use of Drupal modules for administering and supporting collaborative peer-based social learning. The architecture is demonstrated in two learning in 3D prototypes: a 4-H regional youth leadership robotics project involving a collaborative model-based reasoning simulation game on geothermal energy and a lesson on the early history of the U.S. Constitution involving the Thomas Jefferson Dinner Bargain of 1790.

1.0 INTRODUCTION

Visual simulation capabilities offered by 3D virtual worlds provides opportunities for interaction with models in coordinated conjoined action above text toward shareable visual mediums providing a sense of place, space, and physiological embodiment (Thomas and Brown, 2009). While 2D and 3D learning environments can provide for high levels of interactivity, 2D synchronous learning suffers not because of a lack of interactive tools but because of a lack of a sense of immersion in the activity itself (Kapp & O'Driscoll, 2010). Coordinated group action and problem solving in the use of 3D virtual simulations and models can extend across boundaries of physical and virtual worlds. Participants in virtual world spaces can be supported in the extension to physical world meetings and activities. Likewise, the flow of social groups in collaborative activities can be supported in both directions across virtual and physical spaces to better situate learning with the depth of experience that results from connections to everyday life. In this way, learning can be increasingly untethered to home, work, or school spaces by using a combination of mobile, virtual, and social networking technologies. Learning in hybrid, blended-environments of this kind have been labeled 3rd-space for how primary and secondary content and learning settings can be bridged across culture, schools, peer groups, homes, and communities (Gutierrez, et al., 1999; Godwin-Jones, 2005).

Learning in 3D offers the means for observing and manipulating normally inaccessible objects and variables in the form of visual simulations and models operating in immersive space. Learners can make use of immersive interactive 3D simulations and models to make what is abstract and intangible concrete and manipulable to better grasp abstract concepts. Learning inquiries can take the form of "what-ifs" for studying how variable changes result in differing process dynamics and outcomes depicted by a visual simulation or model.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **2011**	2. REPORT TYPE	3. DATES COVERED **00-00-2011 to 00-00-2011**

4. TITLE AND SUBTITLE **Third-space Architecture for Learning in 3D**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Air University, ,Maxwell Air Force Base,Montgomery,AL,36112**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S)
	11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
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14. ABSTRACT
Learning can be increasingly untethered to home, work or school spaces by means of integrative cloud services coupled with 3D worlds, and mobile, collaboratively driven use of digital ?third space.? A 3rd-space, portable and modular design is described and demonstrated for use in administering and supporting learning in 3D. 3rd-space environments can be designed for enabling multi-purpose, multifunctional devices and tools for learner-centered design and collaborative social learning. The framework offered in this paper supports multiple delivery options involving offline and online access to an OpenSim platform for learning in 3D and the use of Drupal modules for administering and supporting collaborative peer-based social learning. The architecture is demonstrated in two learning in 3D prototypes: a 4-H regional youth leadership robotics project involving a collaborative model-based reasoning simulation game on geothermal energy and a lesson on the early history of the U.S. Constitution involving the Thomas Jefferson Dinner Bargain of 1790.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Public Release**	**8**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

2.0 THIRD-SPACE ARCHITECTURE

The learning in 3D prototypes described in this paper are enabled by the following 3rd-space architecture components (Figure 1):

a) Open source Drupal content management system offering social networking tools for supporting instructors and learners across blended-learning environments involving the use of web-based learning management systems and 3D worlds,
b) Open source OpenSim 3D immersive world supporting avatar-based interactivity with learning challenges, objects and tasks; access is provided through open-source browsers that can connect via the Internet or offline to the OpenSim world supporting the challenge,
c) Open source MySQL database for storing and supporting challenge data exchange and persistence across Drupal and OpenSim,
d) Open source PhP and LSL scripting engines for interfacing between objects and avatars and supporting client-server data exchange,
e) Postcast email server supporting email communications across Drupal and 3D world,
f) Open source Apache web server supporting Internet access to the 3D world via client web browser,
g) Open source Android and Apple XCode for developing mobile apps (note: Unity3D can also be used to help bridge between 3D worlds and mobile apps),
h) Open source Blender for developing imported models,
i) Skype for supporting in-world group communication,
j) In-world simulation engine developed for on-demand access to learning resources and interactive features presented by the challenge (supporting 3rd-space accessibility in a social learning environment),
k) In-world assessment, data collection, modeling, and reporting tools,
l) In-world instructional design studio for supporting adaptations of the challenge by instructors; the design studio also provides background information on learning research employed in the challenge,
m) In-world robotics simulation kit used by learners to repair geothermal stations;

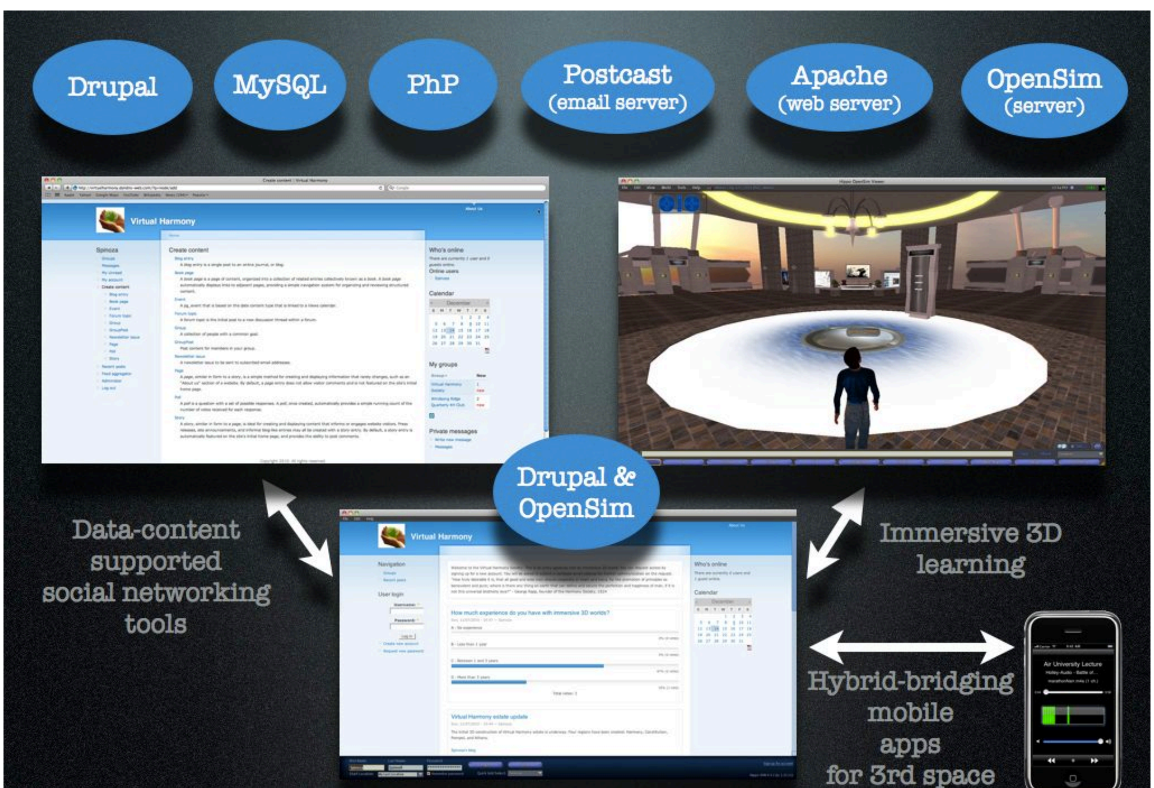

Figure 1. 3rd-space architecture components.

kit components support modular and incremental constructions of robotic devices and controls for use in-world,

n) Interactive challenge learning technologies include virtual computers, media (audio, video, and voice), simulation engines, on-demand rezzing of models, 3D concept mapping, knowledge acquisition and skill performance monitors.

Altogether, the architectural components provide the means to support mobile and immersive learning in 3rd space. Benefits of the architecture include:

- Tapping into and leveraging the innovations occurring in the open-source communities involving rapidly changing and dynamic development environments surrounding mobile and 3D worlds,
- Developed applications and learning resources are coupled with interactive and immersive 3D learning tools and environments to fully leverage the benefits of situated and social learning and advances in the learning and assessment sciences,
- Applications are supported in both online and offline operation modes providing for greater portability and behind-the-firewall use options, and
- Support for distributive and collaborative design and prototyping in-world where the applications are developed, assessed, and used.

3.0 LEARNING DESIGN

The learning design used in the 3rd-space prototypes is based on situated learning by using scenarios and information visualization involving model-based reasoning (MBR) activities (Figure 2). Scenarios are designed to engage learners in challenges by applying knowledge and problem-solving skills. Effective learning challenges are those that can successfully engage learners to formulate intuitions about the challenge based on prior knowledge and experiences for successful application in solving problems.[i] Challenges can leverage affective learning benefits derived from game structures such as the use of quest-oriented tasks. Model-based reasoning activities help learners uncover important relationships about applying knowledge and how concepts are used and relate to each other for developing deeper and enduring understanding. Overall, challenges can be used to help the learner develop:

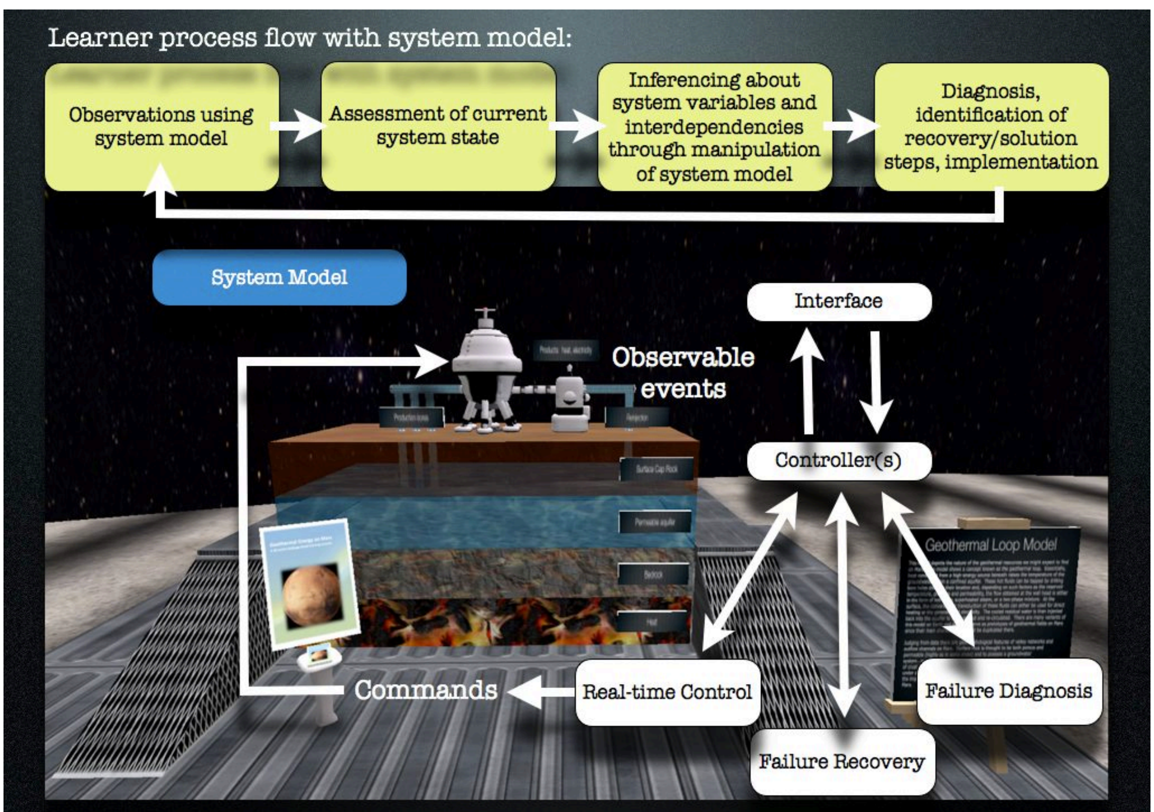

Figure 2. Model-based reasoning architecture.

- Awareness of own thinking
- Effective plans
- Increased awareness of and use of resources
- Improved skills to evaluate the effectiveness of actions
- Skills to take a position when the situation warrants it
- Ability to engage intensely in tasks even when answers or solutions are not immediately apparent
- Increased desire to push the limits of knowledge and abilities
- New ways of viewing a situation outside the boundaries of standard conventions

3.1 Challenge Learning Flow

The learning flow of the challenge begins with the introduction of a grand challenge or problem sufficient to capture the attention and imagination of the learner. Each of the five phases of the challenge flow helps the learner in the acquisition and application of knowledge necessary for critically understanding concepts at a deeper level (Figure 3). At each flow point (A thru E) the learner is provided with Vygostky-like scaffold assistance, including encouragement to consider multiple perspectives on the challenge, revise earlier positions as needed, commit to a position or solution, and communicate the underlying rationale for the position or solution. Throughout the flow, challenge data and performance indicators are collected and accessible by learners and instructors for assessing and evaluating learning progress and outcomes. Attention is now turned towards describing how the architecture and challenge designs are represented in each of the two prototypes highlighted in this paper: the Geothermal Energy on Mars and the Dinner Bargain of 1790 challenges.

4.0 CHALLENGE PROTOTYPES

The two challenge prototypes described in this paper were crafted using a collaborative design studio process. Basically, the design studio process involves the use of processes, tools, and virtual spaces to support the exploration, imagineering, and creation of innovations involving new media (Stricker, et. al., 2010).

For learning innovations, involving new media, there is a need to acquire a fundamental understanding of how best to design learning environments for supporting the variety of ways people interact with new media and with each other in new socio-technical relationships

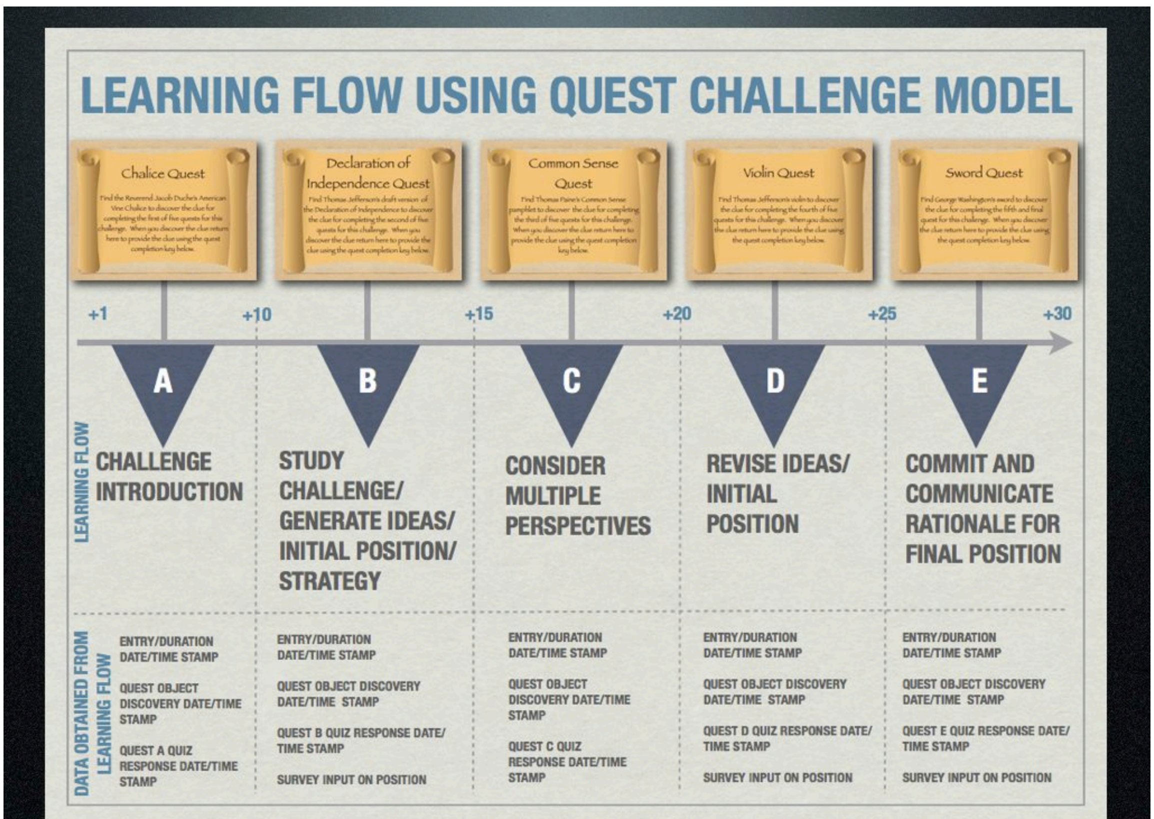

Figure 3. Learning challenge structure and flow.

independent of geographical distance and proximity (Stricker, 2009; Bailenson, et al., 2008; Allen, et al., 2004; Kakihara & Sorensen, 2002; Bransford, et al., 1999; Cognition and Technology Group at Vanderbilt, 1997). Broad concepts or ideas can be taken from discovery inception to prototype exemplars by leveraging multiple areas of expertise of participants involved with the design studio.

4.1 Geothermal Energy on Mars

This challenge was crafted to support 4-H regional youth leaders in the development of science, technology, engineering, and mathematics (STEM) skills and application in collaborative problem solving using robotics concepts. 4-H leaders and volunteers from Auburn University collaborated in the design and prototyping of the challenge. This challenge uses a combination of MBR activities along with quest-oriented tasks in the design.

4.1.1 Challenge Background

Mars offers the best prospects for human exploration of another planet due to its abundance of indigenous resources for supporting a permanent and self-sufficient ecosystem necessary for sustaining life on the planet. Three energy sources offer prospects for sustaining a human ecosystem on Mars: sun, wind, and geothermal (Fogg, 1997). A viable Mars ecosystem rests on whether energy resources can be harnessed profitably. In other words, net energy would need to be obtained above the energy required to harness it. This challenge explores proposed methods of generating net energy power on Mars necessary to sustain human life and civilization. In particular, geothermal energy prospects are examined in depth by the learning challenge.

At the beginning of the challenge learners receive an orientation on space travel to Mars at a virtual rocket launch facility that includes MBR activities using a system model of geothermal energy. Following orientation and MBR activities, the learner then virtually travels to a Mars geothermal station located on the Cerberus Plains.

On the journey, the learner continues to acquire knowledge and understanding about each energy source prospect for sustaining a human ecosystem on Mars and why a geothermal energy station was established on the Cerberus Plains. Learners are presented with the STEM behind the decision to build and operate a geothermal energy station on the Cerberus Plains. Upon arrival at the geothermal energy station, the learner is asked to apply what they've learned on the challenge to diagnose and repair a Mars geothermal system. Challenge activities can be adjusted to better fit desired learning objectives and difficulty appropriate for age and subject knowledge levels. Problem solutions involve the application of STEM skills in the use of robotic kits to make station repairs. Hinting and assistance are provided within the immersive 3D world challenge.

The learner is presented with the following grand challenge:

"What criteria are best to successfully assess power supply options for sustaining human life on Mars?"

The learner is also requested to describe and justify the application of their criteria in their solution for repairing a Mars geothermal system. Learners are guided through challenge phases with instructional scaffolding delivered on the basis of a framework supporting 3rd-space social learning using an anchored instruction model. The challenge can be completed individually or by collaboration in teams.

4.1.2 Challenge Enduring Understandings

The overall focus of the challenge design is on effective learning. Design features emphasize developing and deepening enduring understanding of important ideas (Wiggins & McTighe, 2005). For the Geothermal Energy on Mars challenge, the enduring understandings are:

a) Importance and value of data and models for supporting scientific inference and decisions,
b) Application of STEM skills involved with scientific model-based reasoning supporting critical thinking and methods to collaboratively solve problems, and
c) Necessary and sufficient net energy criteria and features required for Martian settlements

4.1.3 Challenge Prototype Assessment

Each prototype undergoes a series of Alpha and Beta testing to assess the design, usability, and expected learning outcomes. Participants in the testing include samples of subject matter experts, instructors, IT specialists, instructional designers, and learners. Alpha and beta testing is planned using samples of 4-H leaders and members.

4.2 Dinner Bargain of 1790

This challenge was crafted to support a set of Reserved Officer Training Corp (ROTC) lessons on the U.S. Constitution and early American history. ROTC leaders and instructional designers from the Holm Center at Air University collaborated in the design and prototyping of the challenge. This challenge primarily uses quest-oriented tasks in the design.

4.2.1 Challenge Background

Thomas Jefferson arranged for a private dinner at his residence on 20 June 1790 to see if a "bargain" could be agreed upon for resolving conflict surrounding the revolutionary war debt. The immersive 3D world challenge context places the learner back into a virtual-world simulated time of 1790 in New York City just prior to Jefferson's famous dinner.

The learner has opportunity to explore the perspectives and issues behind the Sunday dinner conversation at Jefferson's home and formulate a response to the following grand challenge:

"Was the dinner bargain of 1790 really a "bargain" for the new nation? Justify your response with facts and interpretation of the events and issues behind the dinner bargain."

Learners are encouraged to examine the following questions to effectively address the challenge:

- How were the founders of the new nation planning to address the revolutionary war debt? What was at stake with the solution?
- How was the residency question for the new capital related to the debate on how the new nation should pay her war debts? What was at stake with the solution?

A common or shared solution to each question above was not immediately forthcoming to the founders of the new nation. Perspectives and solutions offered by the founders occurred in the context of a deeper debate over federal versus state sovereignty and alternative national visions. The following virtual scenes are emphasized in the challenge:

- <u>Fraunces Tavern</u>: this is where the challenge is introduced and initial explorations occur by learner to formulate an initial response to the challenge question. Perspectives on the questions/issues from the founders of the new nation can be discovered and learned from interacting with objects/devices within the environment. Also, while at the tavern, learners hear about the important dinner being planned by Jefferson. The tavern structure consists of two exploratory floors containing clues, hints, and interactive objects.
- <u>Jefferson's residence</u>: this is the location of the dinner reenactment and discussion leading to the historic compromise. Further research can be conducted by the learner at this location in support of revising the initial response to the challenge question.
- <u>Other locations</u>, such as George Washington's quarters, are provided for exploration and learning about the issues/tensions surrounding the context of the challenge.

4.2.2 Challenge Enduring Understandings

The Dinner Bargain challenge helps the learner to explore and develop deeper insights and value for why the American revolution was extraordinary and how tensions at its founding are inherent in the American experience and challenges facing the nation today.

The big idea and deeper understanding for the learner to discern, by engaging in the challenge, is how the revolutionary generation found a way to contain the explosive energies of the debate in the form of an ongoing argument or dialogue on tensions that was eventually institutionalized and rendered safe by the creation of political parties. Further, the tensions at the creation of the new nation remain and underlie much political debate today:

- Conflict between state and federal sovereignty
- Conflicting attitudes toward government itself
- Competing versions of citizenship
- Differing postures toward the twin goals of freedom and equality

4.2.3 Challenge Prototype Assessment

Learner interaction with scene devices actions and their responses to challenge questions are recorded and used in the feedback loop (Figure 3). Hints, clues, research information and resources are also provided

through interactive devices. Alpha and beta testing data are used to improve the challenge design and prototype.

5.0 CONCLUSION

Understanding how learning functions in 3rd space can be extended through the use of architectures uniquely designed for enabling learning in 3D. The utility of such architectures lies in how well learning and assessment sciences are integrated with new media capabilities. Early work on the 3rd-space prototypes suggests learning in 3D, using mobile, interactive and immersive challenge scenarios, constitute an entirely new learning environment full of prospects for actively engaging learners regardless of location.

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Biographies

Andrew Stricker serves as a distributed learning architect for Air University by helping to design, develop, and implement advanced and emerging learning technology innovations into U.S. Air Force educational and professional military education programs. Previously, Dr. Stricker served Vanderbilt University as associate provost for innovation through technology. He has also served 28 years as an Air Force officer and scientist specializing in learning sciences and human-factors engineering. Dr. Stricker

studied at Texas A&M University and Yale University. His research is focused on modeling adaptive expertise and the design of learning technologies.

John Cook is a professor with the College of Education, Auburn University and serves as an Extension 4-H Specialist in Science & Technology Literacy. He develops and implements programs relating to the mechanical sciences, new technology, and science literacy. His responsibilities also include assisting county extension agents in planning, organizing, conducting and evaluating Science & Technology and other programs. Dr. Cook has served as a member of a National 4-H Task Force on Science, Engineering, and Technology from 2007-2010 and continues as a member of the National 4-H Science Management Team.

Kimberly Combs-Hardy received her Ph.D. in Educational Psychology from Baylor University with an emphasis in Adult Learning and Creativity in 2000. She was a faculty member with Troy University with teaching responsibilities in Technology, Research, Statistics, Cognitive Development and Adult Learning. In late spring of 2010, she joined Holm Center Curriculum Directorate as the Chief of Educational Technology, where she continues her passion on the effective use of technology in the classroom.

Cynthia Calongne is a professor with the Institute for Advanced Studies at Colorado Technical University. Her research blends computer science, virtual worlds, emerging media, game design, usability, and robotics as well as future and innovation methods. She was a featured author in the *Educause Review* (October 2008).

Elizabeth Stricker serves as a 4-H volunteer for the Youth Leadership program for Alabama. Her undergraduate degree is in Management Information Systems, University of Maryland, with graduate studies in creativity from Texas A&M University. She worked 15 years as a project manager and instructional designer for Booz-Allen Hamilton. Elizabeth has also been the director of the online learning team at Texas A&M University, and educational technology director for VaNTH at the School of Bioengineering, Vanderbilt University.

Kathryn Flitter has supported the Product Data Acquisition & Implementation Support Team at Naval Surface Warfare Center, Carderock Division (NSWCCD) for over 20 years. Kathryn has provided technical support to Naval Sea Systems Command (NAVSEASYSCOM) Program Offices seeking to convert their legacy technical data products to an XML standardized format. Most recently, she has provided support to the Virginia Class Submarine Acoustics Program for conversion from a proprietary data format to the ISO S1000D. Kathryn is currently supporting the NSWCCD Director of Innovation in the implementation of virtual world technology for the development of immersive sailor training.

Toni Scribner has over 22-years of service with the Air Force and is currently serving Air University as an Educational Technology Innovation Analyst. She consults and assists AU faculty in designing, developing, and implementing emerging learning technologies and principles into Air Force educational and professional military education programs. Research interests include educational and instructional technology tools, instructional design, learning theory, and faculty development.

Fil Arenas retired from the military after 28 years of faithful service (14 USAF and 14 USN), as a Lieutenant Commander, he served as a Medical Service Corps officer until retirement in February 2005. He attained his M.S. degree in Management Science from the State University of New York in 1987 and his Ed.D. degree in Higher Education Administration from The George Washington University in 2005. Dr. Arenas is currently an assistant professor of Organizational Leadership at the Squadron Officer College since August 2007 and an adjunct professor at Troy University, Montgomery campus in graduate studies.

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[i] The underlying design of a learning challenge is based on situated cognition theory and anchored instruction (see Brown, et. al., 1989; and Bransford, et. al., 1990; Lave & Wenger, 1991). Situated cognition theory places importance on engaging learners in authentic contexts to learn and perform involving problem solving to resolve complex or ill-defined problems. Anchored instruction involves the use of goal-based scenarios. Goal-based scenarios involve the use of real-life challenges (anchors) to engage the learner in realistic contexts for constructing and applying knowledge.